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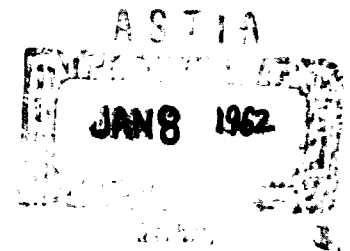
# INDUSTRIAL ENGINEERING DIVISION

Lake City Arsenal

Independence, Missouri

ENGINEERING FOR PRODUCTION OF CARTRIDGE,  
20MM, HPT, M54E2

I. E. D. REPORT NR. 61-15



PROJECT: OAC 5749

OCTOBER 1961

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INDUSTRIAL ENGINEERING DIVISION  
LAKE CITY ARSENAL  
Independence, Missouri

ENGINEERING FOR PRODUCTION  
OF CARTRIDGE, 20MM, HPT, M54E2

Industrial Engineering Division  
Report No. 61-15

Project Number  
OAC 57-49

October 1961

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FRANK W. LITTLEFORD

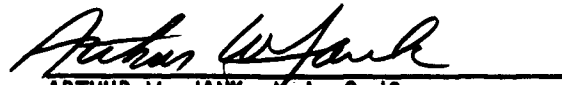
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## TABLE OF CONTENTS

	<u>Page</u>
I. ABSTRACT	1
II. INTRODUCTION	2
III. PROCEDURE	3
IV. RESULTS	4
V. CONCLUSIONS	5
VI. RECOMMENDATIONS	6
VII. APPENDICES	7
Appendix A	8
Design T46, Dwg. FC 5950	
Design T51, Dwg. FD 18218	
Appendix B	11
Proj., 20mm, HPT, M54	
Drawings D7553822	
D7553823	
C7553824	
Appendix C	15
Proj., 20mm, HPT, M54E2	
Drawings D7258859	
D7258860	
Appendix D - Physical Constants	18
Appendix E - Distribution List	19

1. ABSTRACT

Feeding and ramming difficulties during short burst automatic fire with the Cartridge, 20MM, HPT, M54 were traced to the external configuration of the projectile nose; a redesign being indicated. Frankford Arsenal developed the T46 and T51 Projectiles which proved satisfactory in limited tests. The T46 closely followed standard (M55) Projectile design, but the T51 was completely unconventional, being of one-piece construction. The central portion of the body O.D. was reduced for weight control, giving it a distinctive "dumbbell" shape (See drawing in Appendix A). A cost study by IED indicated the T51 design to be the more economical to manufacture and its unusual shape made it inherently identifiable. The one-piece construction also eliminated nose assembly difficulties and security problems during feeding and ramming. Minor design and dimensional changes were made to the T51 projectile to promote volume production and it was designated the M54E2. Engineering for production was completed with the satisfactory production and acceptance of a production quantity of 121,000 Cartridge, 20MM, HPT, M54E2 at LCA.

It is recommended that the Cartridge, 20MM, HPT, M54E2 be standardized as the Cartridge, 20MM, HPT, M54A1 for procurement where high pressure test ammunition is required for use in 20mm aircraft weapons of the M39 or M61 type.

## II. INTRODUCTION:

The Cartridge, 20MM, HPT, M54 was developed by Frankford Arsenal to meet the requirement for ammunition loaded to 120% service pressure for weapon and barrel acceptance purposes. In the course of development of this cartridge, it was found expedient to obtain the required excess pressure by utilizing a projectile weighing 1965 grains instead of the normal 1521 grains weight of service projectiles. The heavier (2,000 grains) M99 Projectile modified by cutting off the tip of the nose to achieve correct length was found to meet these requirements and was subsequently utilized in the Cartridge, 20MM, HPT, M54. After standardization of the M54 Cartridge, difficulties were attributed to interference of the square or flat meplat on the nose of the modified M99 Projectile with the gun feed chuting and feeder which were designed to accommodate the rounded nose of the standard service ammunition.

Frankford Arsenal accordingly initiated development of a new item and generated two designs. One of the designs, T46, is a modification of the current M55 Projectile design (smaller cavity), but the other, T51, has an unusual external configuration, the body being solid and having metal removed from the O. D. for weight control. This results in a "dumbbell" shape. Limited tests of these two designs conducted by Frankford Arsenal were satisfactory.

As a result of the continuing technical liaison maintained with Frankford Arsenal, initial engineering for production of the M54E2 Cartridge was initiated by the IED, LCA, to coincide with completion of development by Frankford Arsenal.

During the latter part of 1956, Lake City Arsenal was assigned a production order for a quantity of approximately 120,000 Cartridges, 20MM, HPT, M54. Because of difficulties encountered in meeting ballistic acceptance requirements (pressure) in the production of these cartridges, completion of the engineering for production of the Cartridge, 20MM, HPT, M54E2 was expedited by the IED, LCA.

Since M99 Projectiles were unavailable, it was a propitious time to make a design change.

III. PROCEDURE:

The T46 and T51 sketches forwarded from Frankford Arsenal were studied, indicated changes made, and were placed on Ordnance format drawings.

A cost and feasibility study was made by IED to determine which of the two FA designs was the more economical to manufacture, and which would result in the more satisfactory over-all item. Drawings were forwarded to prospective vendors for comment as to producibility and cost. Suggestions resulting from this survey were evaluated and those found valid were incorporated into the item selected.

Test quantities of the selected item were manufactured by the Contractor-Operator, LCA. Minor dimensional difficulties in the nose area were encountered and drawing changes were made as required. Firing tests were conducted to determine if interference problems had been corrected.



The latest rotating band seat configuration was applied to the LCA sketches of this projectile for uniformity of tooling and economical purchase of band blanks.

Projectile weight was specified at 1965  $\pm$  10 grains per ballistic studies made by the Ballistic Engineering Branch, Industrial Engineering Division. (See IED Report No. 58-4).

Action toward a new purchase description for the projectile described herein was initiated by Lake City Arsenal.

#### IV. RESULTS:

The cost and feasibility study indicated the T51 design projectile to be cheaper than the T46 to manufacture even by commercial vendors who were currently producing the M55A1 and A2 Projectile which is very similar to the T46 design. In addition, its one-piece construction eliminated nose assembly costs and security problems, and provided positive identification with its unconventional "dumbbell" shape.

Vendors reported that the T51 design would present no major manufacturing problem, except that at least one-quarter inch (1/4") length was required forward of the rotating band for the rechucking operation (trim band, reduce heel diameter, cut crimp groove, and cut radii on heel).

Initial test quantities manufactured at Lake City Arsenal by the Contractor-Operator indicated that minor dimensional changes were necessary. These were the dimensions which control forming of the nose portion of the projectile. The 1.086" - .020" nose length dimension was too restrictive when using the 30° basic angle specified. Also, it was

found that the front bourrelet would be as short as .114" under certain conditions. The nose angle was changed to  $32^{\circ} 30' \pm 0^{\circ} 30'$ , the nose radius to .130" + .005 , and the nose length to 1.020" max. A bourrelet length of .180" approximate was assured by the above dimensional changes.

A study of ballistic problems associated with this projectile has been prepared and published as Industrial Engineering Division Report No. 58-4, entitled "Ballistic Study of Projectile, HPT, 20MM, M54E2".

Purchase Description LCA-PD-3 covers specifications for and inspection of Projectile, 20MM, HPT, M54E2.

Approximately 11% of the first 92,000 items produced were outside the specified weight limits. Examination of the production records indicated that 99.2% of the last production lot met the specified weight tolerance of  $1965 \pm 10$  grains. This percentage figure closely approaches the AQL (Acceptance Quality Limit) recommended for the weight characteristic in the specification (LCA-PD-3) prepared for this projectile.

Physical constants were measured and are contained in Appendix D of this report.

#### V. CONCLUSIONS:

Results of the initial production engineering study indicated the FA T51 projectile design to be preferable to the FA T46 design on the basis of:

- a. Cost
- b. Elimination of nose assembly costs and nose security.
- c. Easy and positive identification. Eliminates need for stannic stained cartridge case.

The Projectile, 20MM, HPT, M54E2 as production engineered by the Industrial Engineering Division, LCA, satisfactorily meets all ballistic and functioning requirements.

V. RECOMMENDATIONS:

It is recommended that the Cartridge, 20MM, HPT, M54E2 be standardized as the Cartridge, 20MM, HPT, M54A1 and that any future requirements for the ammunition be fabricated as this cartridge.

**VII. APPENDICES.**

**APPENDIX A.**

Design T46, Drawing FC 5950  
Design T51, Drawing FD 18218

**APPENDIX B.**

Projectile, 20mm, HPT, M54  
Drawings D7553822  
D7553823  
C7553824

**APPENDIX C.**

Projectile, 20mm, HPT, M54E2  
Drawings D7258859  
D7258860

**APPENDIX D.**

Physical Constants.

**APPENDIX E.**

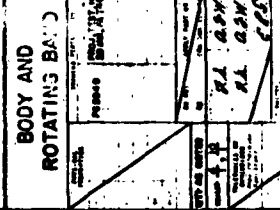
Distribution List

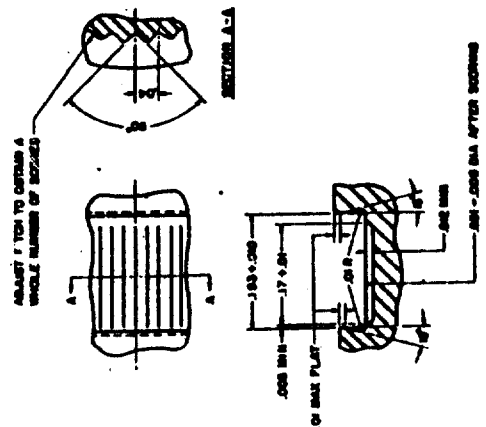
## **APPENDIX A**

**Projectile, 20MM, HPT:**

**Design T46, Dwg. FC 5950**

**Design T51, Dwg. FD 18218**





DETAIL OF BAND SEAT  
ALTERNATIVE-- 120° MECHANICAL SCISSORS MAY BE USED  
SCALE--  $\frac{1}{4}$

[illegible]

**VIEW OF ROTATING BAND AND CRIMPING GROOVE**

[illegible]

**PEPPER  
FARM, LTD.**

0001's AGM

FRANKFORD AFFIDAVIT  
ORDNANCE CORPS  
BUREAU OF THE ARMY

**BODY AND  
ROTATING BAND**

**APPENDIX B**

**Projectile, 20MM, HPT, M54:**

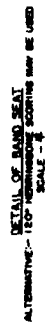
**Drawing D7553822**

**Drawing D7553823**

**Drawing C7553824**







**BODY**

\* STEEL - 901-5-43  
CUTTING  
CUTTING  
CUTTING

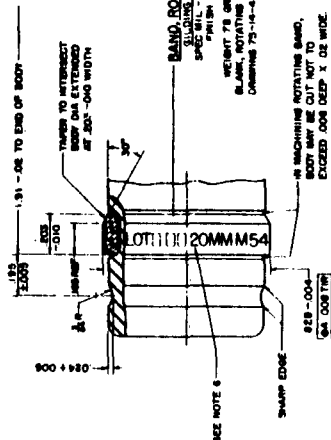
STEEL 901-5-43

AISI C1132 @  
AISI C1144 @ \*

FINISH 125 / EXCEPT AS NOTED

WEIGHT 1597 GRAMS APPROX

**BAND, ROTATING**  
GLIDING METAL  
SPEC MIL - 8 - 2029C  
PARTIAL 123



**VIEW OF ROTATING BAND  
AND CRIMPING GROOVE**

[illegible]



1. DIMENSIONS FOR WHICH NO TOLERANCES ARE GIVEN SHALL NOT BE GAGED EXCEPT FOR SPECIAL CONTROL AS PILOT LOT INSPECTIONS.
2. HOLES MAY BE CURED AS DESIRED EXCEPT MAX DIA OF CAVITY SHALL NOT EXCEED .448.
3. REMOVE ALL BURRS.
4. MAY BE VARIED TO OBTAIN REQUIRED WEIGHT.

NOTICE - THIS DRAWING SHALL NOT BE USED  
FOR REPRODUCED EITHER WHOLLY OR IN PART  
EXCEPT WHEN AUTHORIZED IN CONNECTION  
WITH UNITED STATES GOVERNMENT PROCUREMENT.

[illegible]

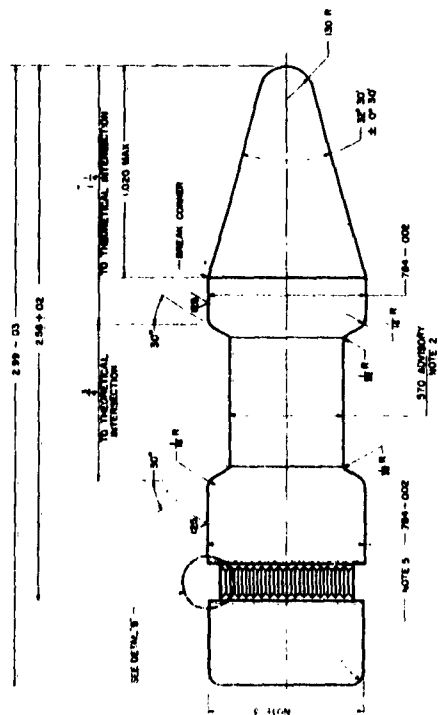
**APPENDIX C.**

**Projectile, 20MM, HPT, M54E2:**

**Drawing D7258859**

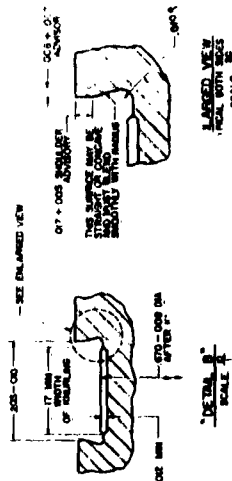
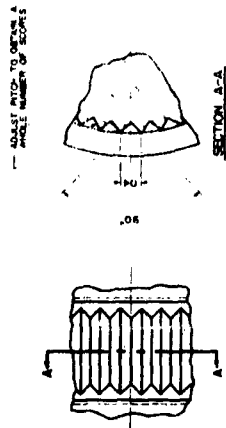
**Drawing D7258860**





**220. ALL OVER EXCEPT AS NOTED**

- NOTES: -
- 1 SPECIFICATIONS WL-6-2300, WL-STD-8, WL-STD-10 AND LCA-PO-8 APPLY
  - 2 THIS SWITCHING MAY BE VAIRED TO CONTROL WEIGHT
  - 3 CUMULATIVE BASE TO BE 780-004 ON PRESSED BODY AND NOTATIME BAND ASSEMBLY BEFORE PARTING.
  - 4 BODY WEIGHT SET ON APPROX. TO BE CONTROLLED TO MEET WEIGHT 780-003 ON RECALCULATED TOTAL OF 780-003
  - 5 PEOPLE ON PRESSED BODY & NOTATIME BAND ASSEMBLY TO BE 780-003 ON RECALCULATED TOTAL OF 780-003



CALL TOLL FREE 800 725 8860

**BODY**

ORDNANCE CORPS  
BAPT OF THE ARMY  
LAME CITY ARSENAL  
NORTHVILLE, MICHIGAN  
7258860

7258860

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 EXCEPT WHEN AUTHORIZED IN CONNECTION WITH  
 UNITED STATES GOVERNMENT PROCUREMENT

## APPENDIX D

### Physical Constants of M54E2 Projectile

Lot Nr. - LC-3-4-57  
Axial Moment, A - 8.1306 gm - in<sup>2</sup>  
Trans Moment, B - 80.7287 gm - in<sup>2</sup>  
Center of Gravity - 1.52 cal from base  
 $A^2/B = .8189$   
 $\frac{2B}{A} - 1 = 19.858$

**APPENDIX E**  
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